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RAT PROOFING A MUNICIPAL SEWER SYSTEM.

A REPORT OF AN INVESTIGATION TO FIND A PRACTICAL METHOD OF RAT PROOFING THE SEWER SYSTEM OF SAN FRANCISCO.

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The city sewer system may be considered a permanent harboring place for rats, and it provides, in addition, a convenient and extensive highway for their rapid travel from one point of the city to another.

To a considerable extent rats enter and follow this highway in their migrations from house to house, and the number present in sewers bears a somewhat definite relation to the number infesting bordering premises. The rat proofing of the city sewers would not only reduce the danger of spread of disease by rats, but would reduce the number of rats infesting such premises and prove an important element for their general control and final elimination.

An examination of the rat-trapping records of this office indicates that about 13½ per cent of all rats trapped are caught in the sewers. These rats were trapped through the use of 252 cage traps, representing 2.9 per cent of the total traps in use in the city.

Rats may enter sewers in four different ways:

First. Through the catch basins at present in use at the corners of city streets.

Second. Through house sewer systems, where the premises have remained vacant for a period of time, which has resulted in the evaporation of the water contained in the various traps.

Third. Through laterals from the main sewer system which extend to vacant lots and there find openings on the surface. Such laterals represent abandoned house sewer systems following the destruction of the buildings by the fire of 1906.

Fourth. Entrance is effected wherever the discharge pipes of the system are above low tide.

Without doubt the majority of rats enter and leave the sewers by means of the numerous and convenient corner catch basins, and the report contained herein will be confined to the discussion of the rat proofing of catch basins alone. The rat proofing of house sewer systems in vacant premises, the closure of open laterals in vacant lots, and the question of lowering the outfalls which remain uncovered at low tide will not be considered at this time.

Catch Basins.

It is stated by the city engineer's office that there are at present in use in this city approximately 20,000 catch basins, consisting of three general types:

First. The old type, comprising 40 per cent, 8,000.
Second. The modern type, comprising 40 per cent, 8,000.
Third. The reconstructed type, comprising 20 per cent, 4,000.

The first, or old type, consists of an elliptical basin measuring 3 feet by 5 feet and having an average depth of 7 feet. This basin is divided by a brick wall, a portion of the wall being omitted below to provide a water trap. The water from the street enters through a vertical opening in the curb. This type of trap was found to be in very poor condition, and in every instance where examined, dry or semidry sediment was found present up to the sewer outlet. However, a vigorous clean-up of catch basins has put them in fair condition in certain sections. In nearly every instance this sediment contained rat burrows, which extended under the dividing wall and afforded easy passage to rats from the streets. The walls were not plastered, and, being rough, afforded sufficient foothold for rats to climb to the curb inlet. Many of these basins were badly in need of repair.

Type No. 2 is the form constructed under present contract work. It consists of a half-spherical and half-square pit, with a horizontal opening in the street near the curb. The cover of this type consists of two series of rectangular openings about 1½ inches in width. The trap used is a mechanical device, consisting of a flap door of cast iron that opens when the water reaches a certain point in the basin and closes automatically by force of gravity. From actual examination, however, few of these flap doors were found operating properly. Some were rusted in an open position, but the majority were held open by sticks or some form of débris that had fallen into the catch basin. Sediment was found up to the level of the sewer outlet in most cases examined. The interior walls were not plastered, and rats could come and go at will.

The third type represents a reconstructed form. The pit is the same as in the second type. The traps are of the water type, constructed of quarter bends of vitrified pipe. The walls of such basins, where found smoothly plastered on the inside, and where the outlet provided was not less than 3 feet from the top of the street inlet, were considered rat proof. It is believed that this remodeled form of trap, when properly reconstructed, is rat proof, but frequent cleaning will be required to remove accumulated sediment.

It is stated that a gang of three men with a wagon and driver can clean about 12 basins per day. With six gangs operating it would require 277 days to get around and clean each basin once. The following estimate covers approximately the cost of such cleaning:

Eighteen men clean 72 basins per day.	
Cost for labor, 18 men, at $3 per day	$54
Cost for teams and drivers, 6 men, at $5 per day	30
Cost of 6 gangs per day	84
Six gangs clean 20,000 basins in 277 days at a cost of $84 per day.	
Total cost for cleaning each basin once in 277 days ($84 by 277)	23,268

Since these gangs are continuously employed throughout the year of 300 working days, the total cost per year for the cleaning of catch basins would be 300 times 84, or $25,200.

The various types here outlined were all carefully examined in order to determine why they are not rat proof. This was found to be due to several causes:

First. The openings in basin inlet gratings, necessary for the proper admission of storm waters or other water accumulating in the street, were in every case sufficient in size to permit the easy passage of rats.

Second. The traps of very few of the basins examined contained water, and in a city with a long dry season, unless mechanically filled with water, such traps are ineffective as such, and in the absence of water offer no obstruction to the passage of rats to and from the sewer.

Third. Practically all catch basins contained dry or semidry sediment up to the opening of the trap outlet to the sewer. This sediment raises the bottom of the basin to within from 20 to 27 inches of the street inlet. Rats very readily jump 2 feet vertically, and coming from the sewer easily leap upward the distance required to reach the openings in the street gratings.

An attempt was then made to devise some form of catch-basin cover or some practical mechanical attachment thereto, which would prevent the entrance or exit of rats to or from the sewer, and at the same time offer no obstruction to the flow of storm or other water from the street.

A series of 11 experiments, using 20 live rats in actual catch basins, was carried out to prove the inefficiency of the present form of basin and to test the various schemes suggested for improvement, but the ingenuity of the entire force was exhausted without finding a rat-proof cover which was both efficient and practical.

In the series where the distance from the bottom of the basin to the street inlet grating did not exceed 27 inches rats in every instance were able to reach the grating by jumping and escape through its openings.

A series of experiments as follows was then conducted in order to determine the minimum distance rats would be unable to jump in their efforts to escape through openings in inlet gratings:

First. A catch basin was cleaned to a depth of exactly 3 feet and the sewer outlet closed. Six rats were placed therein over night. No rats escaped.

Second. A piece of vitrified sewer pipe 24 inches in diameter was arranged vertically on end. The distance inside from the bottom to the top was made exactly 3 feet 6 inches. Three rats were left therein over night. None escaped.

Third. Eight pieces of vitrified sewer pipe—four 18, two 21, and two 24 inches in diameter, respectively—were arranged vertically on end. The distance inside from bottom to top was made exactly 3 feet. On the top of four pieces of pipe, one for each size, was placed the ordinary catch basin cover. Twenty-four rats were distributed throughout and allowed to remain over night. No rats escaped.

From these experiments it is assumed that a vertical distance of 3 feet between the inlet grating and the bottom of the basin will prevent the escape of rats to the street, provided the walls of such basins are smooth.

It is understood that recently during the dry season an attempt has been made to render the traps in basins effective by cleaning, flushing, and filling the traps with water. Unfortunately the water in such traps has proved an ideal breeding place for mosquitoes. In the investigation of numerous mosquito complaints it has been found that in about 98 per cent of all cases examined the breeding of such mosquitoes was confined to corner catch basins alone. In many instances, on lifting the street grating, the basin was found to be swarming with mosquitoes, while the water in the bottom (sealing the trap) contained thousands of wrigglers. A force of men, constituting a "flying squad," is now engaged, as expeditiously as possible, in cleaning, flushing, and oiling all such breeding places.

From the above it will be seen that catch basins in present use present many objections, which may be stated briefly, as follows:

First. Practically all are nonrat proof.

Second. When such contain water they form ideal breeding places for mosquitoes.

Third. They require an expenditure of about $25,000 per year for cleaning.

Before taking up the question of rat proofing it might be well to consider the need for catch basins.

All examined three months after cleaning were found to be full of sediment up to the trap outlet, which permitted further additions of sediment to enter directly into the sewer. From this it is estimated that 68 per cent of the time the catch basins are not performing their proper function; that is, catching and holding sediment from the street. If no inconvenience is experienced during this large percentage of the time, the inconvenience certainly should not appear during the remainder of the time.

The object of the catch-basin trap is to prevent the escape to the street of gas generated in the sewer. However, since the majority of traps examined were found inoperative and ineffective and no nuisance resulted, it would seem that the presence of the trap is an unnecessary feature and might be omitted. On the tops of hills, however, effective traps may possibly be advisable to prevent nuisance due to the upward draft caused by the steep grade.

Even though effective traps were installed, in the light of present knowledge it is believed that the objection to sewer gas is in most cases unwarranted. Henry N. Ogden, in his volume, Sewer Construction, says:

> The avowed purpose of the traps is to prevent the escape of noisome gases generated in the sewer. But such formation of gas does not or should not occur, and the trap really remains as an evidence of the time when sewers were elongated cesspools and had to be cleaned out with shovels. The smell sometimes detected from a catch basin is due generally to the organic decay in the basin itself and not to any rising from the sewer. Where a proper velocity is maintained in a sewer, there is no opportunity for deposits to form nor for decomposition to take place, and therefore, no gases being generated, the purpose of the trap is defeated.

A proper velocity of water in the sewer has a further tendency to draw in fresh air through the various openings and provide ventilation.

Assuming the above to be true, it is obvious that in practically all cases catch basins and traps can be eliminated.

Rat Proofing of Catch Basins.

From experiments conducted by Creel in Porto Rico, and as the result of our own tests, it has been concluded that the ordinary brown or sewer rat (*M. norvegicus*) is unable to jump upward 3 feet in a vertical direction, and it is our opinion that thorough and satisfactory street drainage and proper rat proofing will be obtained where the form of construction provides: First, a vertical distance of 3 feet between street inlet and sewer outlet; second, laterals which enter at a point below this 3-foot limit; and, third, smooth interior walls with a smooth bottom, presenting sufficient curve to insure the prompt discharge of all sediment into the sewer direct without clogging. It is believed that a form of construction using vitrified pipe of sufficient size and connecting the street openings and the sewer direct will provide these requirements.

This form of construction is recommended for trial, and it is suggested that four such basins be constructed, two in a section of the city where street sweepings and other débris accumulate quickly and where flushing is frequent, and two in a section where débris enters frequently but remains dry because of infrequent flushing. This would determine whether there is danger of clogging and what attention is actually required to keep the basin clean. If found practical this form should be installed wherever the distance between the street opening and the sewer is not less than 3 feet.

The advantages claimed are as follows:

First. Rats from the street may enter the sewer through such basins, but will be unable to return.

Second. Due to the absence of a water trap a potent breeding place for mosquitoes will have been eliminated.

Third. The cost of cleaning catch basins, representing an annual expenditure of about $25,000, will be eliminated.

In order that the various types in use may conform to these requirements the following modifications are suggested:

In the old type of basin sufficient lengths of vitrified pipe, with a reducing elbow to fit the opening at the outlet, will be required. This should be supported on a suitable foundation of brick or concrete, the basin first being filled with sufficient earth to support the foundation and pipe. This modification will permit a direct flow from the street to the sewer and do away with both trap and catch basins. The essential point in the construction is the necessity for 3 feet of smooth pipe in the vertical position to render it rat proof. The size of the pipe to be used in reconstruction is to be left to the discretion of the engineer in charge. The vertical opening in the curb can be closed permanently with brick.

The second type of catch basin could be rendered rat proof in the same way—namely, by the substitution of vertical vitrified pipe with a reducing elbow and the elimination of the traps to prevent their probable clogging.

Cost Data.

Cost of reconstruction of old-type basins.

3 feet of 12-inch vitrified pipe	$1.0125
1 12-inch to 8-inch reducing elbow	1.375
1 yard of dirt to fill in	1.00
2 sacks cement	1.13
½ yard of sand	.50
Labor	10.00
Total	15.0175

The necessary brick for the foundation could be taken from the wall forming the trap.

The cost of reconstructing the "modern type" is approximately the same, $1 being added to cover cost of necessary brick for the foundation, bringing the cost to $16 each.

For the purpose of estimating the cost for the reconstruction and rat proofing of all catch basins it is assumed that 16,000 catch basins (8,000 of the old type and 8,000 of the modern type) will require reconstruction, and that 50 per cent, or 2,000, of the so-called "reconstructed" forms (assumed to be rat proof) will require additional repair at a cost estimated to be $5 each.

The maximum cost may be represented as follows:

Reconstructing 8,000 old type, at $15 each	$120, 000
Reconstructing 8,000 modern type, at $16 each	128, 000
Repairing 2,000 reconstructed forms, at $5 each	10, 000
Total cost	258, 000

Should the form of basin suggested prove practical and require, as assumed, no attention for cleaning, the present expense for cleaning would be eliminated, and in 10 years cover the entire cost of reconstruction. Assuming, however, that it may prove desirable to convert or "reconstruct" all existing catch basins according to methods now in vogue, additional cost data are submitted for comparison:

Original cost of modern type.

Castings (trap and top)	$19. 00
Bricks (1,000)	9. 00
Cement (8 sacks)	4. 50
Sand (1 yard)	1. 00
Labor (excavating)	2. 00
Labor (building)	10. 00
Total	45. 00

The cost to repair them by plastering the interior walls and removing the present traps, substituting therefor the quarter-bend vitrified pipe, would be as follows:

Vitrified bend	$0. 50
Cement	1. 13
Sand	. 50
Labor	7. 00
Total	9. 13

Cost for reconstructing 16,000 basins, using quarter-bend vitrified pipe, providing a water trap, at $9.13 each	146, 080. 00
Repair of 2,000 (50 per cent) already mentioned, at $5 each	10, 000. 00
Total cost	156, 080. 00

This modification would represent a first cost saving of about $100,000, and would be rat proof provided the water trap was kept constantly sealed with water, but it presents numerous disadvantages and is not recommended.

First. Sediment will accumulate in the bottom of such basins. This will require removal at least three times a year, and based on the present cost, where the basins are cleaned but once in 277 days at an expense of $23,268, the cost for labor for such cleaning will approximate $75,000 per year.

Second: To maintain these basins in a rat-proof condition frequent filling of the traps with water will be necessary. This will entail an added expense for labor.

Third. All water traps would require frequent oiling, at considerable expense, to prevent breeding of mosquitoes. Such oiling would be necessary after each flushing of the street or after a slight rainfall, and is of too much sanitary importance to be omitted. Neglect would permit the development of mosquitoes to a serious extent throughout many months of the year and expose the city to mosquito-borne diseases.

Conclusions.

Sewers harbor and provide the means for the spread of rats.

The rat proofing of the city can not be accomplished until the sewers of the city are made practically rat proof.

Rats enter and leave sewers principally through openings in corner catch basins.

Corner catch basins are unnecessary in general sewer construction, and should be installed only when conditions require them.

Mechanical and water traps are unnecessary in properly designed catch basins and should be omitted.

Catch basins, unless designed to permit prompt and direct discharge of sediment into the sewer, should be cleaned at least three times a year.

Water sealing traps should be frequently replaced and oiled to prevent development of mosquitoes.

Recommendations.

That four experimental basins be designed as suggested and installed at proper points for trial.

That, if successful, this type of construction be adopted and used to replace all existing catch basins when the distance from the street to the sewer is not less than 3 feet.

That the "reconstructed" form, with water trap, be continued where the distance is less than 3 feet, such basins to be frequently cleaned and such traps frequently filled with water and the water oiled to prevent mosquitoes.

Much of the information contained herein was obtained by Inspectors Ross and Barber. The statistics were compiled and the estimates made by Inspector Barber.